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Investigating the SEI formation in Li-ion batteries

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Lithium-ion batteries (LIBs) represent one of the pillars of the energy transition induced by the climate changes [1]. While the choice of the materials used as electrodes determines the power energy, the voltage window is defined by the thermodynamic stability of the employed organic electrolytes. When cycling the batteries outside the stability window of the electrolyte, it can decompose, and a few Å-thin and chemically inhomogeneous layer called solid-electrolyte interphase is formed on the positive (CEI) and negative (SEI) electrodes. While the SEI is responsible of the initial irreversible capacity lost during the firsts cycles, its electronic insulating character prevents from the short-circuit of the battery and further degradation of the electrolyte upon cycling. It is therefore clear why the understanding of the formation and stability of the SEI is of pivotal importance for improving safety [2], lifespan and power density [3] of the next battery generation. Thanks to its high chemical sensitivity, XPS is the suitable tool to study the heterogeneous and mosaic-like SEI, providing accurate information about its chemical composition. On the other hand, XPS requires UHV environment, and it is extremely surface sensitive, thus ex situ electrodes are heavily manipulated before the XPS analysis to remove the salt excess, inducing significant changes in the SEI [4]. Here we propose two approaches to directly investigate the SEI in the framework of the European Battery Interfaces Genome –Materials Accelerations Platform (BIG-MAP) [5]. First, the solid-liquid interphase is probed through the electrolyte using the dip & pull setup combined with Near Ambient Pressure Photo-electron Spectroscopy (NAP-PES) available at HIPPIE beamline (MAXIV, Lund), where we have investigated the interphase formed on a glassy carbon electrode cycled against metallic lithium as a function of applied voltage [6]. Second, we have studied the formation and stability of the interphase through the solid phase with hard X-rays PES (HAXPES). Therefore, a tailored liquid cell has been designed and developed at GALAXIES beamline (SOLEIL, France), aiming to reproduce realistic electrochemical properties. Preliminary tests showed the feasibility of the HAXPES approach and guided us to optimize the experimental. These two approaches represent a first step towards obtaining crucial information regarding the SEI growth and stability, thus paving the way for future studies on the effect of electrolyte additives and solvent mixtures on battery performances.

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